## EE 221 Midterm

# Exam Booklet

**Name:** _____

**Student number:** _____

**Notes:**

1. **Write down your name and ID.**
2. **This is close-book exam, only 2 pieces of help sheets can be brought to the exam.**
3. **The exam last 2 hours.**
4. **Write your answer in the Answer Booklet. Any answer in the Exam booklet will no be read and checked.**
5. **Hand in both the Answer Booklet and Exam booklet.**
6. **Try to solve the easy problems first, then the difficult ones.**

**Section 1 (26 points):** True or False. Each problem weights one point.

1. A law summarizes a relationship that already exists in nature.
2. A derivation is a formula that we cannot get from other formulas.
3. Norton current in Norton's theorem is defined as the load current when the load resistor is shorted.
4. Copper is a good conductor.
5. The valence orbit controls the physical properties of the atom.
6. A semiconductor is an element with electrical properties identical to those of a conductor.
7. At room temperature, a silicon crystal acts like a conductor.
8. Intrinsic semiconductor has an equal number of free electrons and holes.
9. Forward bias is achieved when the negative source terminal is connected to the n-type material, and the positive terminal is connected to the p-type material.
10. An ideal diode acts like a switch that closes when reverse-biased and opens when forward-biased.
11. The second approximation of the barrier potential of a light-emitting diode (LED) is 0.7 V.
12. A diode that measures extremely low resistance in both directions is called a shorted diode.
13. The half-wave rectifier has a diode in parallel with a load resistor.
14. The bridge rectifier is similar to a half-wave rectifier because it produces a half-wave output voltage.
15. The choke-input filter is often used because of its low cost and light weight.
16. A clamper is a circuit that removes either positive or negative parts of a waveform.
17. A zener diode is a silicon diode that generally operates in reversed-biased condition.
18. A bipolar junction transistor has three doped regions.
19. In an npn transistor, the emitter and collector are both p-type materials.
20. When the ground side of each voltage source is connected to the emitter of a bipolar junction transistor, it is called a common emitter.
21. A bipolar junction transistor should always operate in the active region.
22. A transistor goes into saturation when the collector current has increased to its maximum possible value.
23. The operating point found on a load line is labeled as C because this point is often called the cut-off point.
24. The two basic kinds of transistor circuits are rectifying and oscillating.
25. Hard saturation of a transistor results when there is just enough base current to cut-off the transistor.
26. Switching circuits are usually designed to operate at saturation and cutoff regions.

**Section 2 (50 points):** Multiple choices, select the most appropriate one. Each problem weights 2 points.

1. The ideal approximation is sometimes called:
   a. first approximation
   b. second approximation
   c. third approximation
   d. Fourth approximation

2. The term stiff voltage source refers to a voltage source with a load resistance which is:
   a. 10 times larger than the source resistance
   b. 100 times larger than the source resistance
   c. equal to the source resistance
   d. 100 times smaller than the source resistance

3. Thevenin voltage is defined as the voltage across the load terminals when:
   a. the voltage source is removed
   b. the load resistor is open
   c. the load resistor is shorted.
   d. the voltage source is shorted

4. What type of atoms is added to molten silicon in order to increase the number of free electrons?
   a. pentavalent b. trivalent c. covalent d. positive

5. What is the most popular and useful semiconductor material?
   a. silver b. copper c. aluminum d. silicon

6. When reverse bias is increased in a silicon diode
   a. forward current increases
   b. depletion layer widens
   c. depletion layer becomes smaller
   d. the diode becomes polarized

7. What is the term for reverse current on the surface of a crystal?
   a. crystal current
   b. reverse current
   c. surface-leakage current
   d. avalanche breakdown current

8. What kind of a device is a diode?
   a. Bilateral b. Linear c. Nonlinear d. Unipolar

9. How much current is there through the second approximation of a silicon diode when it is reversed biased?
   a. 0 b. 1 mA c. 300mA d. None of them

10. If the bulk resistance is zero, the graph of a forward-biased diode above the knee voltage becomes
   a. Horizontal b. Vertical c. None of them

11. How is the power dissipation of a diode calculated?
   a. diode current times diode resistance
   b. diode voltage divided by diode current
   c. diode voltage times diode current
   d. diode current divided by diode voltage

12. A reverse voltage of 10 V is across a diode. What is the voltage across the depletion layer?
   a. 0 V b. 0.7 V c. 10 V d. None of them

13. The reverse saturation current doubles when the junction temperature increases
   a. 1 °C b. 2 °C c. 4 °C d. 10 °C

14. A transformer has a turns ratio of 2:1. What is the peak secondary voltage if 115 V rms is applied to the primary winding?
   a. 57.5V b. 81.3 V c. 230 V d. 325 V

15. If line frequency is 60 Hz, the output frequency of a bridge rectifier is
   a. 30 Hz b. 60 Hz c. 120 Hz d. 240 Hz

16. What is the peak load voltage in a full-wave rectifier (not a bridge rectifier) if the voltage of secondary winding is 20 V rms? Use second approximation for the diodes in the rectifier.
   a. 13.4 V b. 14.1 V c. 26.9 V d. 28.3 V

17. If the load current is 5 mA, the line frequency is 60 Hz, and the filter capacitance is 1000 uF, what is the peak-to-peak ripple out of the a bridge rectifier?
   a. 21.3 pV b. 56.3 nV c. 21.3 mV d. 41.7 mV

18. With the same secondary voltage, which produces the least load peak-to-peak voltage?
   a. Half-wave rectifier
   b. Full-wave rectifier
   c. Bridge rectifier
   d. impossible to say

19. In order to maintain a constant output voltage, the zener diode
    a. must be connected to a transformer
    b. must remain forward biased
    c. must remain in the breakdown region
    d. must be in series with a filter capacitor

20. In a npn transistors, most of the electrons that flow through the base will
    a. Flow into the collector
    b. Flow out of the base lead
    c. Recombine with the base holes
    d. Recombine with the collector holes

21. A bipolar transistor acts like a diode and a
    a. Voltage source  b. Current source  c. Resistor  d. Power supply

22. An npn transistor is base-biased. If the base current is 100 mA and the current gain is 30, the emitter current is
    a. 3.33 mA  b. 3 A  c. 3.1 A  d. Don't know

23. If a transistor operates at the middle of the load line, a decrease in the base resistance will move the Q point
    a. Down  b. Up  c. Nowhere  d. Off the load line

24. Amplifiers that use emitter bias have Q points that
    a. are immune to changes in current gain
    b. move up or down the load line with changes in current gain
    c. are not on the load line
    d. are at saturation or cutoff

25. If the current gain is unknown in an emitter-biased circuit, you cannot calculate the
    a. Emitter voltage
    b. Emitter current
    c. Collector current
    d. Base current

## Section 3 (24 points): Calculations (<u>solve only four out of the five problems</u>). Each problem weights 6 points.

**Problem 1:** Someone has provided me with a two-terminal "mystery circuit", telling me only that the components inside will create a linear I-V relationship.

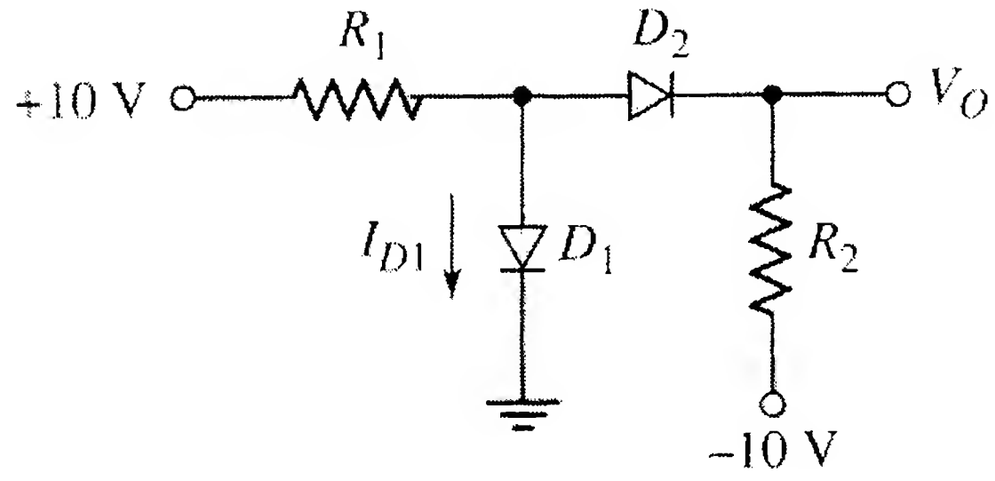
To identify the Thevenin equivalent for the circuit inside, I use a voltmeter to measure the voltage from terminal A to terminal B when nothing else is connected. The reading is 200 mV.

Then I measure the current flowing from terminal A to terminal B, through an ammeter connected from A to B. The reading is 10 mA.

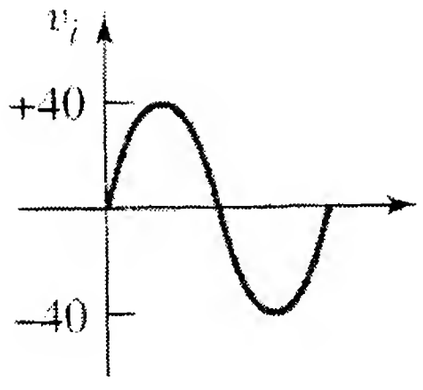
Assuming the voltmeter and ammeter are ideal, Can you find out the Thevenin voltage $V_{TH}$ and Thevenin resistance $R_{TH}$? If you cannot, why?

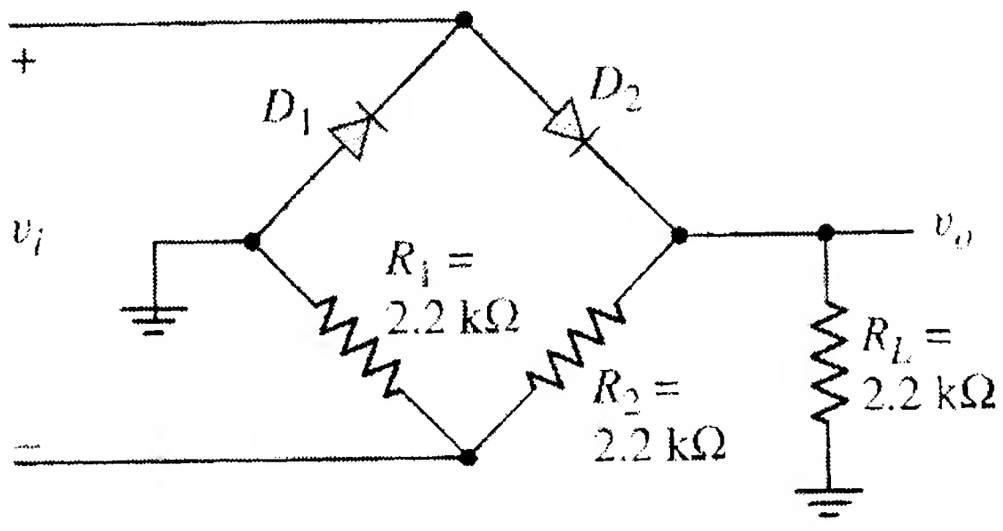
**Problem 2**: Given a silicon diode with a reverse current of 5 uA at 25 °C and 100 uA at 100 °C, calculate the surface leakage current.

**Problem 3:** Find $I_{D1}$ and $V_O$ for $R_1 = 5\ K\Omega$ and $R_2 = 10\ K\Omega$. Use second approximation for the diodes.




**Problem 4:** Sketch $V_O$ versus time for the circuit below with the input shown. Use the first approximation for the diodes.



**Problem 5:** There is a LED driver circuit shown in the following diagram. The zener diode breakdown voltage is 5V. The potential barrier $V_{LED}$ of the LED is 2V. Calculate the current $I_D$ through the LED when $V_{BB} = 0$ V. Find out the current $I_D$ again when $V_{BB} = 10$ V.